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Experiments in the potentialities of glazes developed from naturally occurring minerals and industrial waste products common to Potsdam, St. Lawrence County, New York

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EXPERIMENTS IN THE POTENTIALITIES OF GLAZES DEVELOPED FROM NATURALLY OCCURRING MINERALS AND INDUSTRIAL WASTE PRODUCTS COMMON TO POTSDAM, ST. LAWRENCE COUNTY, NEW YORK

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INTRODUCTION

In an effort to reduce shop costs, a local, natural source of clay was sought.

The fact that early settlers had established temporary brickyards to furnish their building needs, indicated that clay was readily found in the area. However, it was curious to note in a detailed history of the region, that there was no account of a pottery having existed.[1]

The first sample of clay taken did not prove useful as a body at stoneware temperatures, but showed possibilities as the major portion of a slip glaze. As a result, experiments were then conducted in the development of ceramic glazes which were derived from naturally occurring minerals and industrial--lumbering and mining--waste products common to Potsdam, St. Lawrence County, New York.

A study of the history and geological survey, historical accounts of industry, and the procurement of raw materials from sites of known deposits were necessary to render this project physically perceptible.

Technical research included empirical, tri-axial and line blends of various materials to discover glazes

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[1]Franklin B. Hough, St. Lawrence County New York History (Albany: Little and Company, 1853), 713 pp.

suitable for stoneware temperatures.

Selected glazes were then applied to a complete set of dinnerware and assorted pots in partial fulfillment of the requirements for the Master of Fine Arts degree.

CHAPTER I

LOCATION, DESCRIPTION AND PROCESSING OF MATERIALS

I. GENERAL LOCATION

The materials used in the glaze tests subsequently described, were found within a thirty mile radius of Potsdam, St. Lawrence County, New York, as indicated on the map, Figure 1, page 2.

The geographical area between the Adirondack Mountains and the St. Lawrence River has an abundance of natural minerals. These are either in the form of glacial till (a glacial drift consisting of an unassorted mixture of clay, sand, gravel and boulders), or outcroppings of igneous and metamorphic formations exposed as the glacier receded.

Some of these, as in the case of the feldspar, had given rise to commercial ventures, some of which are still in operation. The Green Hill Mining Company mined feldspar near DeKalb Junction from the early part of the century until it ceased operations in the late 1930's.[2]

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[2]D. H. Newland, C. A. Hartnagel, "The Mining and Quarry Industries of New York State for 1927 to 1929," New York State Museum Bulletin No. 295 (Albany: University of the State of New York, 1932), p. 36.

Talc mining is presently a major industry in the Gouverneur area where the Gouverneur Talc and the International Talc Company are located.

Iron mines are still in operation southwest of Potsdam.

The slag piles of abandoned pyrite diggings near Canton proved to be a source of clay and minerals with high iron oxide content.

In addition to the feldspar, talc and clay previously mentioned, the other local materials used in the tests were: skutterudite, a mineral containing variable amounts of nickel, iron, and cobalt, and is classified as an ore of whichever metal is dominant[3], quartz, sand, dolomitic limestone, dolomitic marble, and wood ash.

II. MATERIAL DESCRIPTION, SOURCE, PREPARATION AND FUSION TEST RESULTS

Potsdam clay. The Potsdam clay, a common surface type dug four miles northeast of Potsdam, was gray-green in color and of a very gummy consistency. This clay, in slip form, was passed through a 30 mesh screen to remove large stones and organic matter. The slurry, or fluid mud, was dried, crushed, and passed through a

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[3]Herbert S. Zim, Paul R. Shaffer, Rocks and Minerals (New York: Golden Press, 1957), p. 44.

50 mesh screen. A fired sample applied as a glaze slip, was dark red-brown with green spotting at cone 9. The surface was largely pinholed.

Wood ash. The first and second collections of wood ash were labeled "I" and "II", respectively. They were obtained at Green's Sawmill, Sanfordville. The first sample was taken from the slab burner which is used to dispose of log trimmings. The unburned scraps indicated that a large portion of the ashes was from soft wood.

Water was added to the ash and the resulting liquid was passed through a 60 mesh screen. The ash was allowed to settle and the water was decanted. This process was repeated four times. After the last washing, the decanted liquid was clear and tasteless, which implied that most of the soluble alkalis were removed by washing. The ash was then dried and pulverized for use.

A sample of this ash fired at cone 9 showed little fusion where the application was thickest, with some indication of glass formation at the edges of the test tile where it was thinnest.

The processing of the second sampling of ashes varied from the first, whereby an 80 mesh sieve was used and the water was changed and siphoned twice. The water tasted bittersweet which indicated that not all of the soluble alkalis were removed by washing.

This was done intentionally to retain the fluxing power of these materials.

This sample formed a thin, semitransparent gray-green glaze at cone 9.

Dolomitic limestone. Dolomitic limestone was procured from the Barret Chemical Company quarry in Norwood.

The sample tested was a minus 20 mesh grade which was processed by the firm for use as agricultural lime.

The limestone was mixed with water and poured through an 80 mesh sieve. The material that passed through the screen was allowed to settle and the water was carefully poured off. The sediment was dried and tested for fusion at cones 8 and 9.

At cone 8, there was no evidence of fusion. The cone 9 test showed very little fusion and the surface of the sintered limestone could easily be scraped away.

Feldspar. Feldspar is found in many small outcroppings in the Potsdam area.

The simplest method of getting sufficient quantities for tests was to collect it at the dumps at the site of the former Green Hill Mining Company.

The feldspar was combined with quartz. Identification was made by observation of the cleavage, which is almost at right angles, and by simple scratch tests with

quartz, an unskilled method of measuring the hardness of this mineral.[4]

The material was crushed with a hammer and dry-sifted through an 80 mesh screen. It was then passed through a sample grinder.

Tests using the feldspar mixed with water as a glaze slip, were fired at cones 8 and 9. The cone 8 tests showed complete fusion, but the surface was too rough for use as a glaze.

The cone 9 tests formed a glaze with a good surface, was gray-white in color, and semitransparent due to the bubbles trapped in the glaze.

Quartz. Quartz and sand provided the silica. The former was found at the site of the Green Hill Mining Company. Identification was made by observation, cleavage, and scratch tests.

The material was crushed and sifted in the same manner as the feldspar.

There was no fusion observed on the test tile fired at cone 9.

Sand. Exposed sand dunes are quite prevalent in this region, being the remainder of pre-historic Lake Iroquois.

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[4]Zim, Shaffer, op. cit., p. 18.

It was very light in color, almost white, and so fine that the grains easily passed through a 30 mesh screen. The sand did not fuse at cone 9.

Liver clay. The liver clay was dug at the site of an abandoned pyrite mine near Canton. It was on the surface of the hill at the mouth of the shaft. The labeling was suggested by the color of the material.

Black streaks were revealed in the cross section of the clay when the lumps were broken with a shovel. The material was free of organic matter and large pieces of gravel.

The clay was dried and crushed with a mallet, after which it was sifted, dry, through an 80 mesh sieve.

The clay was well fused at cone 8 and was dark red-brown in color with a dry, rough surface.

The cone 9 test was similar in texture, but the color was darker.

Ochre clay. Under the liver clay was a layer of ochre colored clay. There was an absence of organic material and coarse gravel. It had a large amount of plasticity when mixed with water.

It was crushed and screened in the same manner as the liver clay.

The fired properties differed greatly from the liver clay. At cone 8, a semimatte, bright red-brown

glaze formed with a badly crawled surface.

The cone 9 test was darker, but the crawling remained severe.

Skutterudite. Crystals were found protruding from the rock face at the mouth of the pyrite mine. Identification was made by its silvery metallic color and streak plate tests. Streak is the color of the powdered mineral best seen when the mineral is rubbed against a streak plate of unglazed porcelain, such as the back of a tile. It is worth noting that in metallic ores, the streak may differ from the color.[5]

The crystals were picked from the matrix with a knife point, were crushed with a hammer, and sifted through an 80 mesh screen.

The powdered crystals, unaltered, were fired at cone 8. They did not fuse, but turned an iron-red color.

The material was then added to a white base glaze and fired at cone 9. A five per cent addition of the crystals resulted in a brown color typical of that made by nickel oxide. When another five per cent of the crystals were added, it produced a darker brown glaze. No further tests or samples were fired using skutterudite as a colorant as it was difficult to get sufficient quantities for general use in glaze-making.

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[5]Zim, Shaffer, op. cit., p. 21.

Talc. To gain more fluxing power, talc was added to the list of materials, the samples having come from the Gouverneur Talc Company. They were in the forms of lump talc as it was taken directly from the mine, and in 100 mesh powder as it is sold to industry.

The sample fired at cone 9 was a clear, transparent glaze, quite fluid, and with a small mesh craze.

Dolomitic marble. The presence of the marble was uncovered in library research on the feldspar in a pamphlet describing the material and location. The marble used came from the same area where sample WC-8, as noted in the literature, was taken.[6]

The chemical analyses of composite chip samples of WC-8 are as follows: SiO_2, 0.23; Al_2O_3, 0.58; Fe_2O_3, 0.07; MgO, 21.2; CaO, 31.2; SO_3, 0.05; CO_2, 45.8; H_2O, no determination.[7]

The marble was crushed by hammering and/or use of the sample grinder. It was screened through an 80 mesh screen.

The cone 9 test showed moderate fusion with some glass formation at the edge of the tile.

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[6]John James Prucha, The White Crystal Dolomite Deposit Near Gouverneur, New York (Albany: University of the State of New York, 1953), 13 pp.

[7]Prucha, op. cit., p. 9.

CHAPTER II

DEVELOPMENT OF A SLIP GLAZE USING POTSDAM CLAY

The first tests made with Potsdam clay were to find a suitable flux to use with the material. Frit 3134, Clinchfield feldspar, frit G-23, and petalite were used. Although the glazes still required additional ingredients to improve the surface, frit 3134 and petalite produced the best melt.

Apart from acting as a flux, it was hoped that the high calcium and magnesia content of the frit would provide the desired bleaching and lighten the color of the resulting glazes.

The frit was increased in five gram increments to a total of 35 parts frit to 90 parts clay.

Test P-2

		A	B	C	D	E
Clay	90					
Frit 3134	10	15	20	25	30	35

As the frit was increased, the glaze lost the brown color and became black and more transparent. The surface was smoother and not yet fluid in the D test at cone 9 oxidation. The glaze had the lustrous-black characteristics of Tenmoku, running to a red-rust on the edges of the tiles in tests B, C, and D. When tile C

was refired at cone 04, it was red-brown in color.

Subsequent tests were made with additions of flint and magnesium carbonate. These tests were bright, semi-transparent, and cloudy due to bubbles trapped in the glaze. No further tests were made in this direction.

Petalite was used as the major flux in the following tests, with additions of dolomite as an auxiliary flux. Also, it was thought that the dolomite, because of the calcium and magnesia present, would help bleach the color of the glaze. Two gram increments, followed by two 5 gram increments, were tried.

Test P-60		61	62	63	64
Clay	60				
Petalite	40				
Dolomite		10	10	5	5

Five grams of tin oxide were added to the remaining glaze slip to see what effect it would have on the surface and color of the glaze. The surface remained smooth as in the P-64 test, but the color, although lighter, had a pastey character.

Test P-63 was the most promising of the series. The surface was bright green-brown with what appeared to be magnesia crystals developing on the surface.

Test P-63A was modified to include ten more parts clay.

Five parts red iron oxide were added to Test B.

Ten parts clay were added in Test C and an additional ten parts clay in Test D.

Test P-63A	63B	63C	63D
Clay	70	10	10
Petalite	40		
Dolomite	25		
Red Iron Oxide	5		

The A and B tests were darker and had a glossy surface. Test C had a smooth, brown surface which was opaque and semibright, with some light brown crystal development at cone 9. The glaze was matte, slightly immature and dark olive at cone 5, but still usable.

When applied to pottery, the discovery was made that the glaze was smoother and had a more interesting surface at cone 6. As the result of an underfired cone 9 kiln, it was found that the glaze developed its best qualities at a well soaked cone 8. The pots from this kiln were a medium olive brown with dark iron specks, semimatte and opaque.

Test D was tried with colorants after an initial addition of five per cent tin oxide was made in the batch. The tin did not affect the surface of the glaze, but the color changed to a flat gray-purple with a scattering of dark brown iron specks at cone 9.

Four per cent manganese dioxide was added to the same batch and fired at cone 9, which produced a smooth, gun-

metal gray colored glaze.

A valuable, yet simple type of methodical blend is the line blend which may reveal interesting combinations between two colorants.[8] Such a blend was set up with the following colorants:

1	2	3	4	5	6
SnO_2	MnO_2	NiO	V_2O_5	CuO	Co_2O_3
.05	.04	.02	.08	.03	.02

In summary, all the additions had similar effects on the original glaze, except vanadium, which caused severe pitting and made the glaze very fluid. The other tests were black or brown-black and showed a slight increase in fluidity at cone 9.

Manganese dioxide produced a rich brown color. Copper and manganese gave a good Hare's Fur effect over CH3 white slip. Other tiles showed mottlings of red-brown, green and gray over a dark background. Although most of the glazes were technically well developed, there was a marked sameness about them that limited their uses.

Test P-63B

Flint was added to this test to aid in the crystal development that was started in the original sample.

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[8]Daniel Rhodes, Clay and Glazes for the Potter (Philadelphia and New York: Chilton Company, 1957), p. 136.

The iron oxide was dropped to lighten the color.

This glaze series was labeled P-70.

Test	P-70	P-71	P-72
Clay	70		
Petalite	30		
Dolomite	25		
Flint		5	5

At cone 9, the surface was made up of semimatte patches of yellow crystals on a bright, dark brown background.

When fired to cone 8, the surface became a solid mass of yellow crystals with dark brown iron spots, similar to the spotting on Test P-63.

Five per cent tungstic acid, a crystallizing agent, was added to further aid the crystal development (P-72X). This glaze gave consistent results with a firing range of cone 6 to cone 9. At lower temperatures, the surface was yellow-green, matte, and slightly rough.

At cone 8, in a well soaked kiln, it was suitable for use on utilitarian pieces, such as dinnerware. It gave good variation in color and texture with overlapping applications.

The crystals separated more as the glaze became more fluid at cone 9. The surface, a dark, glossy brown, broke well over rims and textured surfaces.

The following batch was used in a line blend in search of color variations:

1	2	3	4	5	6
CoO	CuO	FeO	NiO	TiO_2	MnO
1.05	.05	.08	.05	.08	.08

The prevailing colors were dark and the surface of the glazes ranged between the semimatte of the base glaze to the bright, glossy surface of the glazes with a high percentage of colorant.

The cobalt-nickel combination produced a dark, broken, lead cast on the surface.

The nickel and iron combination resulted in a broken spatter of tan and blue-gray on a dark background.

Five per cent copper produced a metallic black with some bright crystals developing on the surface.

Of the glazes covered in this section, P-63 and P-72X were used extensively on pottery, separately and in combination, at cone 8, with consistently good results.

CHAPTER III

WOOD ASH GLAZES

I. WOOD ASH, FELDSPAR AND CLAY

The following tests were based on a formula used by Miss Katherine Pleydell-Bouverie.[9]

Feldspar	40 parts
Ash I	40 parts
Clay	20 parts

The soft wood ash was combined with Clinchfield feldspar and Kentucky special ball clay. The fired glaze was a soft matte buff at cone 8.

Next, other fluxes were substituted for the feldspar. Nepheline syenite gave the best results. The glaze was an off-white semimatte with small brown specks.

Another test was made substituting local feldspar for the commercial feldspar, and ochre clay for the Kentucky special ball clay. The glaze was matte gray, where thin, and semimatte tan in areas of heavier application.

When a suspending agent was used such as three per cent bentonite or three per cent epsom salts, the ash, nevertheless, tended to settle very quickly and the resulting glazes were not predictable.

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[9]Bernard Leach, A Potter's Book (London: Faber and Faber Limited, 1960), p. 163.

In some areas, the glaze had excellent color and surface development, while other portions of the same pot were rough.

II. WOOD ASH AND CLAY

A series of experiments combining ash and clay were made using Korean glaze proportions of three parts wood ash to seven parts clay.[10]

Batch 37

Liver clay	70 parts
Ash II	30 parts

Batch 37-I

Ochre clay	70 parts
Ash II	30 parts

Batch 37 created a glossy off-white opaque glaze at cone 9. Where a second application was made over the first, the resultant color was medium brown.

At cone 8, the glaze showed some pinholing and was darker in color.

The glaze was fluid and became semitransparent when reduced at cone 9. At points where the application was overlapped, the color was pale yellow with blue streaks. Also, some minute spots of bright iron-red were visible.

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[10] W. A. Gilbertson, W. H. Earheart, John H. Koenig, "Ancient Pottery Techniques in Modern Korea," Literature Abstracts of Ceramic Glazes (Florida: College Offset Press, 1951), pp. 296-8.

Batch 37-I caused a bright, black glaze with streaks of a rich plum color breaking through the surface. The glaze was very fluid. Several tests were subsequently made to control the fluidity, yet retain the color, by using talc and marble in separate batches.

Batch 37-II

		A	B	C	D	E
Ash	30					
Clay	70					
Talc		10	20	30	40	50

The addition of talc reduced the fluidity only to a degree in the D test. The plum color was not visible after the B test. The upper portion of the tile had a pronounced streaked effect similar to a Hare's Fur glaze that turned a metallic dark brown on the surf, which is the mass or line of glaze collected at the base of a tile.

Batch 37-III

The additions of marble caused more fluidity and the color changed to a dark olive green. The aventurine character of the glaze with its iron crystals sparkling beneath the surface, was more pronounced as the marble content was increased. As the primary objectives were not fulfilled, no additional tests were made.

Batch 37-IV

The silica content of the base glaze which was thirty parts ash to seventy parts clay, was increased

in four 10 gram installments of quartz.

The plum color did not develop in any of the samples and the surface of the glaze deteriorated as the quartz was increased. There were no usable glazes in the series.

Batch 37-V

The clay was increased to a total of 120 parts clay in relation to 30 parts ash and 10 parts talc. The plum coloring was lost after the first ten-part addition of clay. The glaze assumed an olive green cast with patches of light green crystals which formed on the surface. The first and second steps of the series were good for pottery application.

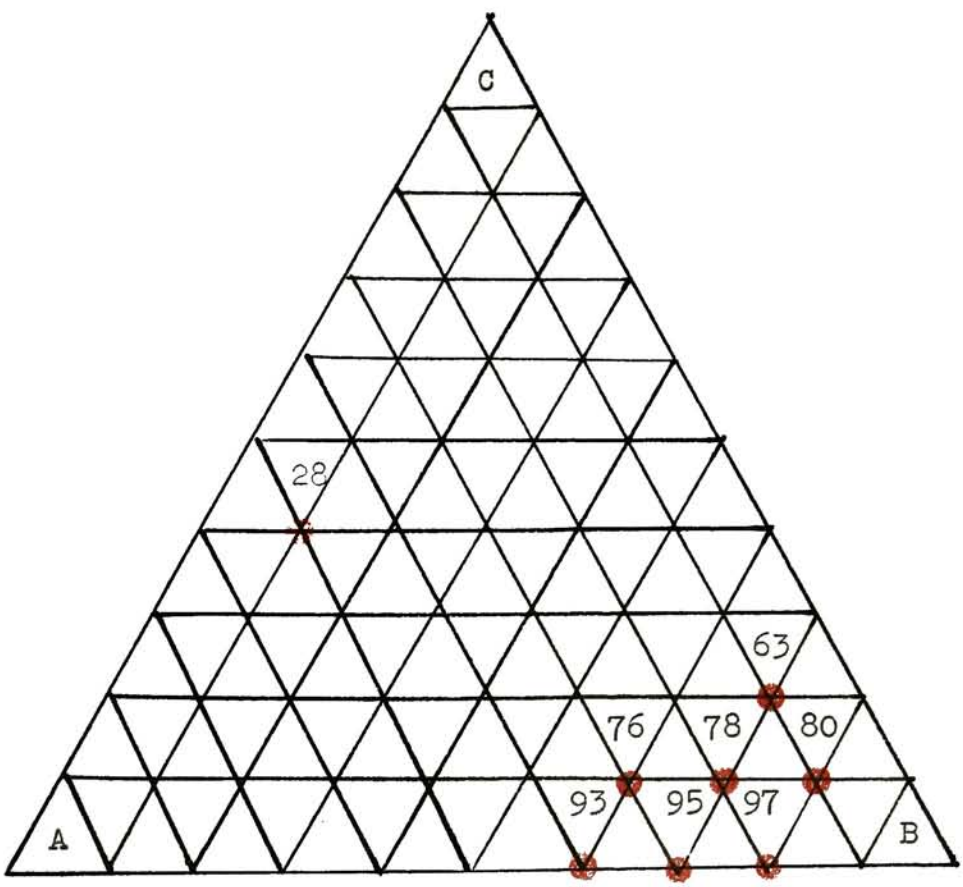
The tests were discontinued at this point since the desired plum color could not be retained. Furthermore, the short firing range and fluid characteristics of the glazes rendered it inadequate for practical purposes.

III. WOOD ASH, CLAY AND DOLOMITIC LIMESTONE

Wood ash, ochre clay and dolomitic limestone were combined in a tri-axial blend as the first attempt to produce glazes entirely from local materials. The test was a wet blend fired at cone 8. Table I, page 20.

TABLE I

WOOD ASH I.....A
OCHRE CLAY.....B
DOLOMITIC LIMESTONE.....C



The glazes with ten to forty parts ash in the batch were typical of high ash glazes. This was a thin, light gray matte with raised, glossy, semitransparent brown or tan patches scattered over the surface of the tile.

Point 28 produced a suitable glaze for jars or vases as some areas remained rough. When applied over a black slip, the blue colorant was predominant rather than the black.

Midway between points B and C, Table I, page 20, the glazes were stony off-white to gray matte until there was a maximum of ten parts limestone in the total batch.

Point 63, 76, 78 and 80, which included ten parts limestone, were a dark olive hue with a matte surface.

Points 93, 95 and 97, combinations of the ash and clay, had bright, glossy surfaces with tan spots over a dark background.

To correct the lack of silica, ten parts of each point was replaced by sand. The sand did not dissolve sufficiently to aid in the formation of the glazes, and left the surfaces rough.

Powdered quartz was substituted for the sand and produced favorable results in the six points tested.

The corrected base points were as follows:

A.	Ash	90
	Quartz	10
B.	Ochre clay	95
	Quartz	5
C.	Dolomite	80
	Quartz	20

Points 93 and 95 were good iron glazes, burnt-orange with dark spots breaking through, bright and opaque.

Number 97 was blue-black with pale yellow specks visible throughout the glaze. The surface was slightly rough, but improved when the glaze slip was passed through an 80 mesh sieve. However, the color was somewhat modified.

It was concluded that the dolomitic limestone was extremely refractory and that more than ten per cent in a blend would cause the glaze to become matte and rough.

In addition, all the usable glazes would require more silica.

Portions of the test were considered for use on pots and as the basis for further analyses.

CHAPTER IV

FELDSPAR GLAZES

I. FELDSPAR, WOOD ASH AND DOLOMITIC LIMESTONE

Feldspar is the base glaze for most high fire glazes. Tri-axial blend, Table II, page 24, was established to develop a white base glaze so as to provide a wider range of color than could be had with the use of iron oxide as an integral part of a glaze batch. Blend T-II was constructed with the following materials and the points labeled accordingly:

A. Dolomitic limestone
B. Feldspar
C. Wood Ash I

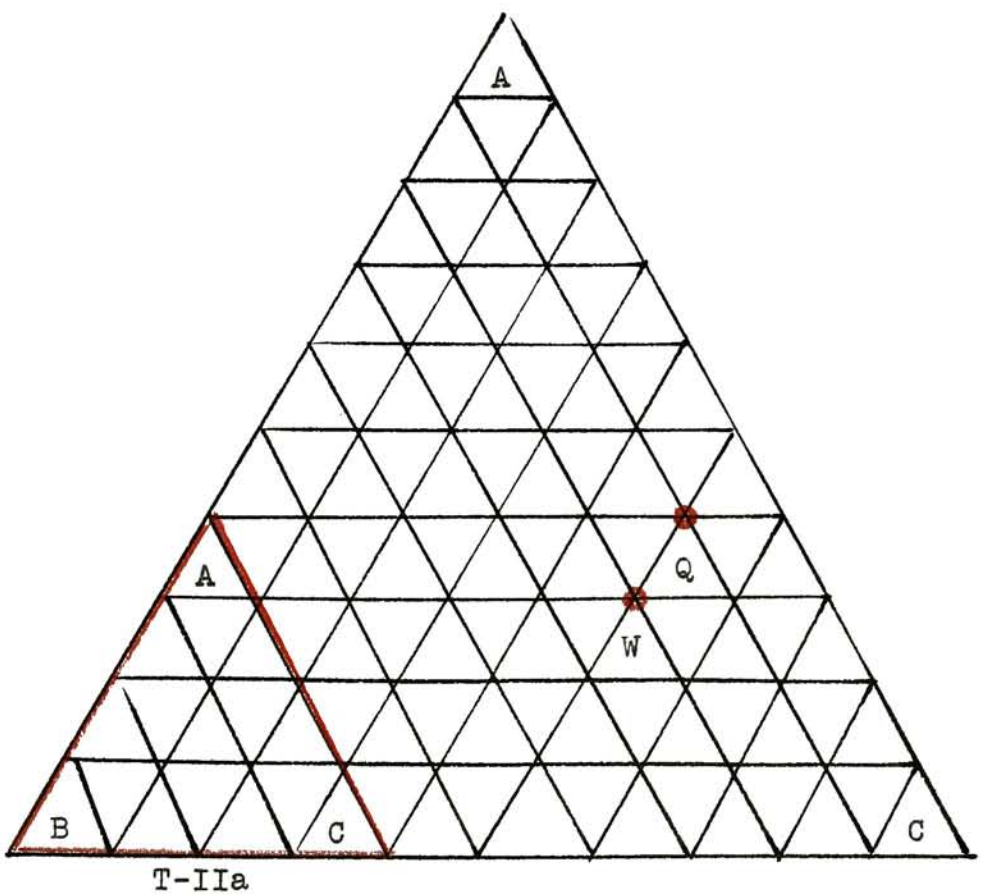
It was known that the materials in the base points did not form a glaze. Therefore, the nine points adjacent to each base point were not blended.

The center points were wet blended and the results of a cone 8 firing were totally immature. Some tiles, refired to cone 9, produced similar results.

Points Q and W were suitable for ceramic pieces such as sculpture, tiles or branch pots, as they were rough in texture and gray, with overcasts of brown and green. The glaze was well fused to the tile and smoother over the black slip.

TABLE II

DOLOMITIC LIMESTONE.....A
FELDSPAR.....B
WOOD ASH I.....C



T-IIa

Further tests, shown in red, were blended in the area of the high feldspar combinations. The points were corrected to the following proportions:

T-IIa

A.	Feldspar	6
	Dolomitic limestone	4
	Quartz	.10
B.	Feldspar	10
	Quartz	.10
C.	Feldspar	6
	Quartz	10
	Quartz	.10

The results of the tests were white to light gray and bubbled at cone 9.

No further tests were made with this combination of materials.

II. FELDSPAR, OCHRE CLAY AND QUARTZ

When tri-axial blend, T-III, was constructed with feldspar, ochre clay and quartz as the ingredients, the results were largely bubbled or pinholed, red-brown glazes.

These tests were not pursued.

III. FELDSPAR, OCHRE CLAY AND WOOD ASH I

A fifteen point tri-axial blend was developed with the following ingredients as described in Table IV, page 27.

A.	Feldspar	100
B.	Feldspar	50
	Wood Ash I	50
C.	Feldspar	50
	Ochre clay	50

In general, the glazes were not interesting in an oxidation firing at cone 9, but showed promise in reduction firings at the same temperatures. In oxidation, they were smooth, bright, and semitransparent, becoming darker and opaque between points B and C.

In reduction, points 4, 8, 11 and 12 produced bright black, opaque glazes with rust spots or streaks.

The mid-points, indicated in red on Table IV, page 27, were compounded in the following manner:

A.	Feldspar	100
B.	Wood Ash I	60
	Feldspar	40
C.	Ochre clay	70
	Feldspar	30

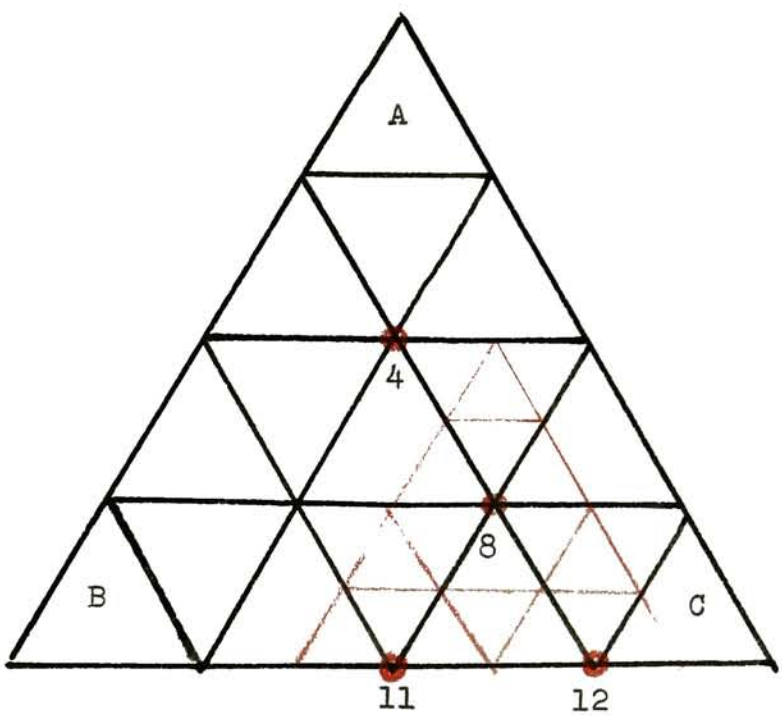
The results showed general improvement in the glaze surfaces and the color characteristics were similar in both oxidation and reduction firings.

IV. FELDSPAR, OCHRE CLAY, DOLOMITIC LIMESTONE AND QUARTZ

The following formula was calculated by assuming the magnesium and calcium content of the dolomitic limestone.

TABLE IV

FELDSPAR.....A
FELDSPAR AND WOOD ASH I.....B
FELDSPAR AND OCHRE CLAY.....C



Test A was compounded on the basis that the limestone was high in magnesium content. Test B was calculated for a high calcium content. It was also assumed that the ingredients necessary to fulfill the requirements of the formula could be supplied by the local feldspar, ochre clay, and quartz.

Three batch recipes were adapted from the original formula, P-81.

Formula P-81

.20 K_2O

.10 MgO .60 Al_2O_3 2.80 SiO_2

.70 CaO

Batch P-81A

Feldspar	145.2
Limestone	73.6
Ochre clay	91.33
Quartz	75.72

Batch P-81B

Feldspar	145.2
Limestone	78.4
Ochre clay	91.33
Quartz	75.72

Batch P-81C

This batch was calculated as a control batch to compare with Tests P-81 A and B for fusion and maturity similarities.

Feldspar	145.2
Magnesium Carbonate	8.4
Whiting	70.
Ochre clay	91.33
Quartz	75.72

Tests A and B were dark green with specks and some pinholing. The control glaze had a brighter surface, semi-transparent, and lighter in color than the tests with local materials. It was interesting to note that the dolomitic limestone comprised approximately 17 per cent of the glaze batch. This was higher than any percentage tolerated in the foregoing tri-axial blends.

Supplemental tests were made with this base, substituting dolomitic marble, talc and equal proportions of both materials.

Jordan clay was used in place of the ochre clay to lighten the color.

The surface was developed sufficiently for use on ceramic ware such as cannisters, jars and vases, but some existing roughness prohibited its use on dinnerware.

The amounts of marble and talc were varied in separate tests to smooth the surface. The increments were altered from 73.6 to 100 grams in 2.5 gram intervals.

As the two fluxes were increased, there was further fluxing evident, but the pinholing became more pronounced.

The tiles glazed with the combination of equal portions

of marble and talc, which replaced the dolomitic limestone, were the most successful. A semiopaque, glossy surface was developed.

To whiten the glaze, opax (a frit) and tin were added as opacifiers in two, separate tests. An addition of five per cent opax produced the best surface and desired opacity. Additional increments did not enlarge upon these improvements.

The use of tin caused a rough surface; therefore, it was eliminated.

The final adjustment of this batch reads accordingly:

Test P-81F

Feldspar	108.9
Talc	27.6
Marble	27.6
Jordan clay	68.4
Quartz	27.

A color line blend was then set up with the above-mentioned formula to which was added six colorants and opax, separately.

1	2	3	4	5	6	7
opax	CoO	Fe_2O_3	NiO	TiO_2	CuO	MnO
.05	~~1.05~~ .015	.08	.05	.08	.05	.08

The addition of manganese was most successful. The surface was completely smooth, the coloring being light tan with dark brown specking.

Other tests showed good color and surface in the iron, nickel and rutile columns. Most of these colors were very low key.

The rutile and opax batches combined to make a light gray-brown.

The cobalt/rutile combination produced a soft, speckled gray with a good surface.

Manganese, at eight per cent, made a light, speckled brown with a bright, smooth surface.

The iron and manganese combined resulted in a darker brown with the same surface as the aforementioned test.

Use of the blue colorants, cobalt and copper, did not produce satisfactory colors or surfaces.

A chance supplement of ten per cent rare earth hydrate caused an off-white, opaque glaze with occasional iron specking and a well healed, bright surface. The rare earth addition seemed to affect the glaze only as a flux.

In order to eliminate the excessive cost of using this material, samples were prepared with zinc or tin to replace the rare earth.

The surfaces of both samples were well developed.

The tin caused the white to have a warmer tone than the zinc test.

V. FELDSPAR, MARBLE AND TALC

Marble and feldspar and talc plus feldspar were combined, in separate line blends, in search of a white glaze.

Blend 1014 was the first of the series.

Step	1	2	3	4	5	6	7	8	9
A	9	8	7	6	5	4	3	2	1
B	1	2	3	4	5	6	7	8	9

"A" is equivalent to 75 per cent feldspar and 25 per cent marble.

"B" is equivalent to 50 per cent marble and 50 per cent feldspar.

The second series, Blend 1014a, which combined talc and feldspar, used the same format for the line blend.

Both series produced gray-white, bright, semitransparent glazes which improved as the 75/25 point combinations increased.

The ninth step of Blend 1014, which consisted of 52.5 per cent feldspar and 47.5 per cent marble, made the best glaze.

The surface was off-white, matte, and showed some crystal development. It was pinholed on the surf.

The talc and feldspar mixture did not produce as good a glaze. It was gray-white, pinholed, and became

more transparent and crazed as the talc was increased.

The ninth step of Blend 1014 was pursued to eliminate the pinholing and to control the crystal development. Two sources of B_2O_3 were added, separately, to correct the pinholing. Raw borax or frit W-15 were added in five gram increments to a total of fifteen grams. Three per cent bentonite was used as a suspending agent.

All the procedures caused an extreme fluxing action which made the glaze bright and transparent, with some crazing, when the total increment was reached.

Another approach to eliminate the pinholing, yet retain the opaque, white matte surface, was to try to extend the firing range by increasing the amount of the fluxing agent. It was not effective.

Ash was used which made a fluid glaze with a thin, matte surface and transparent edges on the test tile.

Cullet and frit 3124 were also tried, in separate tests, as the fluxing agents. In both cases, as the materials were increased, the glazes became brighter, more fluid, and transparent. The original problems of crystal development and pinholing were not corrected.

The third series of tests to improve the glaze surface was by the inclusion of alumina in the form of Bentonite, kaolin, or cryolite.

There was a higher amount of crystallization in the

tests and there was a marked improvement in the surface.

A tri-axial blend was formed with three opaque, white, semimatte glazes that showed most promise.

Ultimately, none produced better results than the marble/feldspar combination, Blend 1014-9. Moreover, none would tolerate color additions, which may have been partially due to the iron content of the glaze and the glaze reaction to the iron content of the clay body.

CHAPTER V

SUMMARY

The employment of rudimentary, natural resources exposed many facets of other areas of learning related, directly or indirectly, to glaze-making which proved to be provocative, enlightening, and resistant.

The experiments contained herein laid the groundwork for extended research with seemingly boundless limits.

This project revealed that it was quite natural to approach each problem and witness the results with reactions that could run the gamut from sheer satisfaction to thorough disappointment. The intangible characteristics sometimes presented a baffling testimonial of its merits, but its attraction was impregnable.

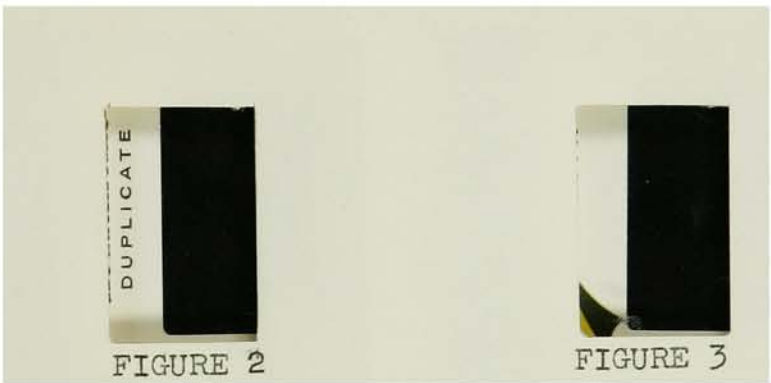


FIGURE 2 FIGURE 3

P-63 C. OXIDATION, CONE 8 AS DESCRIBED ON PAGE 12

FIGURE 4

FIGURE 5

ALL ILLUSTRATIONS
P-72 X, OXIDATION
CONE 8 AS DESCRIBED
ON PAGE 13

FIGURE 6

FIGURE 7

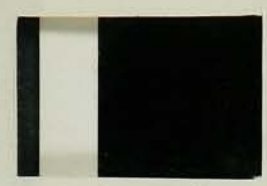


FIGURE 8

FIGURE 9

ALL ILLUSTRATIONS
P-72 X, OXIDATION
CONE 8 AS DESCRIBED
ON PAGE 13

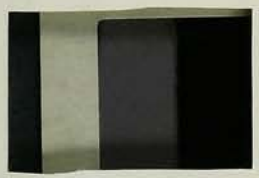


FIGURE 10

FIGURE 11

P-72 X, COBALT AND
NICKEL PANEL
PAGE 15

FIGURE 12

TRI-AXIAL I
POINT 28, OXIDATION
CONE 8, PAGE 21

FIGURE 13

TRI-AXIAL I
POINT 28, OXIDATION
OVER SAND
CONE 8, PAGE 21

FIGURE 14

TRI-AXIAL I
POINT 97, OXIDATION
CONE 9, PAGE 21

FIGURE 15

TRI-AXIAL IV
POINT 12, REDUCTION
CONE 9, PAGE 26

FIGURE 16

P-81, REDUCTION
RARE EARTH HYDRATE
CONE 9, PAGE 28

FIGURE 17

BLEND 1014, OXIDATION
STEP 9 WITH P-63 C
CONE 9, PAGE 32

FIGURE 18

BLEND 1014, OXIDATION
STEP 9
CONE 9, PAGE 32

FIGURE 19

BLEND 1014, REDUCTION
STEP 9
CONE 9, PAGE 32

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